Crosscut Steam Plant
North Side of Salt River near Mill Ave and
Washington Street
Tempe
Maricopa County
Arizona

HAER No. AZ-20

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
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San Francisco, California 94102

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HISTORIC AMERICAN ENGINEERING RECORD

Crosscut Steam Plant
HAER No. AZ-20

Location:	North side of Salt River near Mill Avenue and Washington Street in Tempe, Maricopa County, Arizona. UTM coordinates: 12139865.488N 1351742.384E
Dates of Construction:	Original building for diesel plant, 1937-8; enlarged to house steam plant in 1940-1. Ancillary hydro unit built with steam plant. Indian Bend pump ditch originally constructed in 1921; extended to connect with Salt River Project's Grand Canal sometime before 1940. Indian Bend pond constructed 1941.
Engineers:	Diesel plant designed by Salt River Project engineer T.A. Hayden; other structures also designed by Salt River Project engineers.
Present Owner:	Salt River Project
Present Use:	None of the facilities are in use. The Indian Bend pump ditch, near the pond, and the pond itself have been destroyed. The steam plant and ancillary hydro structures remain standing.
Significance:	The diesel plant housed unique large engines; both the diesel and steam units provided power to the cities of the Salt River Valley during World War II and the very high growth period following. The pump ditch and pond supported operation of the steam plant.
Historian:	Barbara Behan, Salt River Project Archives
Date:	June 7, 1991

The steam plant of the Crosscut power facility at Salt River Project, Tempe, Arizona, has been an important part of the utility's overall power production system. The building first housed diesel engines, then steam generators, which together provided the first non-hydro power to Salt River Project customers. The diesel portion operated from 1937 until 1949, and the steam portion from 1941 to 1974. Both diesel and steam operations were important power sources to the communities of the Salt River Valley, including Phoenix, during the second World War and following, when the Valley experienced tremendous business and population growth. Throughout its history, the diesel/steam plant was significant both to the utility and the surrounding community. As a historic engineering facility, it represented both standard practices and some unique features in power generation of that period.

I. Background: Electric Service at Salt River Project

A. Project History. One of two major power providers to the metropolitan Phoenix area in Maricopa County, Arizona, the Salt River Project has a history dating before statehood. It was established as a federal reclamation project to provide a stable supply of irrigation water to the farmers of the arid Salt River Valley. Between 1905 and 1911, U.S. Reclamation Service (U.S.R.S.) engineers oversaw the construction of the Theodore Roosevelt Dam on the Salt River northeast of the town of Phoenix. This dam was the cornerstone of the Salt River Project, which now manages seven dams on two rivers, an extensive canal network, and a modern electric generation and transmission system.

The U.S.R.S. began generating power at Roosevelt Dam as early as 1904. First conceived to promote irrigation, the Salt River Project only gradually developed its role as the state's second largest electric utility. Over its history, the Project has operated according to a historical reclamation principle whereby a small amount of revenues generated from power production is applied to the cost of providing water. That concept is still in effect at Salt River, although the electric side of the company has come to dominate in many ways.

Organizationally, Salt River Project is divided into two separate entities which reflect its dual role of water and power provider. The Salt River Valley Water Users Association (Association) was formed in 1903 and was responsible for building and managing the Crosscut diesel/steam plant in its early years. The Association still operates the Project's water system. In 1937, the Salt River Project Agricultural Improvement and Power District (District) was incorporated as a political subdivision of the state of Arizona. The District holds ownership of all Project properties except dams and the canal system, which the U.S. government owns. In 1949, the District took over operation of the power production side of the organization.

In 1937, when the diesel portion of the Crosscut facility was built, Salt River Project's electric system was entirely hydropowered. It had expanded significantly since the initial generation at Roosevelt Dam to include hydro plants at three more dams on the Salt River: Horse Mesa, Mormon Flat, and Stewart Mountain. In addition, there were four smaller hydro plants on Salt River Project canals. One of these was the Crosscut hydro plant near Tempe, the site of which was later expanded to house the Crosscut diesel and steam units.

B. Growth of SRP Electric System. In the 1920s, Salt River Project's electric customer base expanded rapidly. In 1922 the Association delivered its first electricity to residential customers, where previously it had sold power only for irrigation pumping, mining, and some small industries. The move to residential service was primarily in response to shareholders in the Association, farmers who could not get power from other providers because rural customers generally were not profitable. In the late twenties, the residential base greatly increased under a "Valley Electrification" program. By the end of the twenties, the Salt River Project electrified rural area was the largest in the world.[1]

Like many parts of the country, the communities of the Salt River Valley were hit with economic hard times during the Great Depression of the 1930s. Agriculture and mining, two of the state's most important industries, both suffered. Many farmers

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[1]Salt River Project, "Long-Range Electric System Plan Phase 1 Study Report: History of SRP's Electric System," by Frank V. Martos and Jerry D. Smith, May 1985, SRP Archives, 4, 8-9; W.J. Grasmoen, H.F. Hudson, "Crosscut--Forty Years of Power Plant Progress," paper prepared for the American Institute of Electrical Engineers Meeting, Phoenix, August 1952, SRP Archives, 1.

with membership in the Salt River Valley Water Users' Association were unable to pay assessments for their water, creating financial difficulties within the Association. Partially in response to this, a new organization "with boundaries and interest practically identical to those of the Association" was formed in 1937 and named the Salt River Project Agricultural Improvement and Power District (District).[2] The District contracted with the Association to continue operating the power and water facilities of the Salt River Project, as the two organizations now jointly were called. Set up as a political subdivision of the state of Arizona, the District was able to refinance existing Association bonds at a lower rate because of tax advantages granted to public agency bonds. In 1949, the Association transferred management of the power system to the District.

As the thirties progressed, there were signs of economic recovery in the Salt River Valley and the SRP. Agriculture was the region's largest industry, and Phoenix was the trading center for Maricopa County. After 1936, domestic and rural customers increased and the Association made improvements to its system, including the completion of Bartlett Dam on the Verde River. By 1939, 70% of Maricopa County retail trade took place in Phoenix, although only 35% of the county's population lived there. A drought in the late thirties and early forties caused power

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[2] SRP, "Long-Range Plan," 11.

rationing in some areas. In response, the Association purchased considerable quantities of power, primarily from the United States and the Arizona Power Authority (Hoover Dam). During the early years of the second world war, load growth in SRP's service territory continued to expand. Through all this, it became clear that the Project needed additional generating capacity. The Crosscut diesel and steam plants were designed to meet this need.[3]

During and after the Second World War, the Salt River Valley saw enormous population growth and economic expansion. Wartime industries prospered in Phoenix and surrounding communities, and post-war growth was especially impressive. Salt River Project's electric system was an important part of this development.

II. Overview of Crosscut Facility

A. Construction. In 1912-14, the Association built the Crosscut hydro generating plant as a source of auxiliary power. Its construction added nearly forty percent to the Project's generating capacity. It was built on the new Crosscut Canal between the Association's Grand and Arizona canals, in Sec. 9 of Township 1 North, Range 4 East, Gila and Salt River Baseline Meridian. This location was selected because two major electric distribution lines passed nearby. The hydro plant provided an important source of power before the Crosscut steam plant was

[3] Ibid., 13, 15; Bradford Luckingham, Phoenix: The History of a Southwestern Metropolis (Tucson: University of Arizona Press, 1989), 106, 109.

built, particularly when there were problems at the larger hydro plant at Roosevelt Dam.[4]

From the time the Crosscut hydro plant was installed until development of the diesel and steam plants, there were few substantial changes at the Crosscut facility. Then from 1937-1941, Salt River Project began expanding its power resources in response to shortages, load growth, and a desire to ease the system's reliance on hydropower. The Project constructed the Crosscut diesel plant in 1937. In 1940, it contracted with the U.S. Department of the Interior for the purchase of power from Parker Dam on the Arizona-California border as another way to add power resources. The following year, the diesel plant building was expanded to house three steam generating units. A fourth permanent steam unit was added in 1949.

Another important program occurred at Crosscut from about 1949-1951, when the SRP electric system was largely converted to 60-cycle from 25-cycle, which was becoming obsolete nationwide. Up to this time, only about a quarter of SRP power was 60-cycle, and a frequency changer existed at the Crosscut site to connect the two separate systems. The first unconverted 60-cycle power was produced at the hydro plant in 1939. The diesel units and first three steam units were installed as 25-cycle and later converted; the fourth steam unit produced only 60-cycle power. After the conversion program, only a small proportion of 25-cycle

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[4]Grasmoen, "Crosscut--Forty Years," 1; "Crosscut," <u>The "Current" News</u> (November, 1964), 6.

power was produced for use by some irrigation pumping and mining customers; this lasted until 1973.

Functions at the Crosscut facility have continued to evolve since the early fifties. Although the diesel and steam units are no longer in service, the hydro plant still produces power during the hot summer months. In addition, the facility today houses central construction and maintenance services for the Project as well as warehouses, records storage, a garage, and administrative offices.

B. Production Statistics. During the years 1938-45, when SRP's electric system was expanded to meet the growing demand for electricity locally, the Project provided power to a variety of customers (See Fig. 1). Among the largest users were the mines near the towns of Globe, Miami, Superior, and others east of the Salt River Valley; other major purchasers of power were local municipalities and utilities, and farmers using electricity for irrigation pumping. Salt River Project also used some of the power itself, as did Valley industries, especially after the start of the war.

The addition of the diesel and steam units at Crosscut provided an alternative to hydropower, which relied on the whims of nature to provide the needed amount of water. However, even after the steam unit was built, the Project's main resource was hydro generation (see Fig. 2). It also continued to purchase large quantities of power, especially during the war years.

Fig. 1

DISTRIBUTION OF POWER SALES BY YEAR

User	Percent of Total		
	1938	1941	1944
Mines	22.2%	44.7%	34.2%
Municipalities/Util.'s	27.2	25.1	23.6
Irrigation Pumping	25.9	20.2	22.5
Industrial	.8	1.0	3.8
Cotton Gins	.2	.1	.1
Misc.	2.3	1.0	2.1
Rural Domestic Service	3.4	4.4	4.1
SRP Uses	18.0	3.4	9.6

Fig. 2

DISTRIBUTION OF POWER SOURCES BY YEAR

Type	Percent of Total		
	1938	1941	1944
Hydropower	79.3%	71.1%	44.5%
Purchased Power	19.3	21.4	41.6
Diesel Power	1.4	4.5	1.0
Steam Power	----	3.0	12.9

Source: SRP Annual Histories 1938, 1941, 1944 (SRP Archives).

III. Crosscut Diesel Plant

A. Background. The purpose for constructing the diesel plant was partly to provide an alternate source of power that did not depend on water. Originally, the Association produced power only as a by-product to delivering irrigation water. As the Project's electric service area grew, it needed an auxiliary power source that was not tied to irrigation demand. The diesel plant provided this. It also would replace power purchased from Central Arizona Light and Power Company, a predecessor to Arizona Public Service Company, under a contract which expired in 1938.[5]

At the time the plant was built, diesel electric power plants were common across the country. For example, a 1939 engineering publication noted that diesel plants were in use at hotels, ice plants, farms, mines, leather factories, newspaper plants, for standby use in hospitals and libraries, and other industries. Many municipal utilities nationwide also employed diesel engines for power generation.[6]

B. Construction. The diesel plant, as constructed, comprised the north end of the existing steam plant building. It was separated from the hydro generating building because that structure was not large enough to accomodate it. It appears that engineers designed the original diesel plant building to accomodate at least some additional equipment in the future, but

[5] F.L. Roe, "Brief History, Electric Power Generation at SRP" (July 16, 1949), SRP Archives, 1; SRP, "Long Range Plan," 13-14.

[6] The Engineering Index (1939), 310.

even this was not large enough to hold all the steam units the Project eventually required. The general contractor for the plant was H.M. Peterson, and Vinson and Pringle Co. was the subcontractor that began work on September 28, 1937.[7]

The building was constructed with reinforced concrete foundations, footings and floors. Steel structural framing was used for the columns, beams, bracing and window casements. A somewhat unique feature for the period was concrete panels on the sides and roof. The low pressure/temperature piping in the plant is mostly flanged construction, and higher pressure/temperature pipes are of welded construction.[8]

The diesel plant had 10,000 kw generating capacity furnished by two 24 x 36-inch double-acting, 2-cycle engines capable of producing 7000 bhp (brake horse power). Both were manufactured by the Hooven, Owens and Rentschler Company, a division of General Machine Corporation of Hamilton, Ohio. They featured a scavenging loop system called the M.A.N. design which was German in origin and produced in the U.S. by the General Machine Corp. Many of the engines' parts were manufactured in Germany (see Appendix A for additional engineering details). In addition to the engines, the diesel plant housed two 6250 KVA, 25-cycle generators and auxiliaries for them direct connected to the

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[7]F.C. Henshaw to Stevens Manning, Sept. 20, 1940, SRP Archives; Interview with Don Squire, Salt River Project, Nov. 9, 1990; 1938 SRP Annual History.

[8]Memorandum from Don Squire, Salt River Project, April 19, 1991.

engines. Engineers designed the plant to be operated completely independent of the hydro plant, anticipating that the diesels would require little attention.[9]

Salt River's diesel engines were unique in that they were very large, mechanically complex, and uncommon in the United States. In 1939, they were the largest diesels in the country, along with some of the same type at Vernon, California. The largest diesel in the world, located at a Copenhagen, Denmark utility, delivered 22,500 bhp compared to 7000 for these. At the time the SRP diesels were installed, two-cycle engines were common, especially for ones with high bhp. A diesel engineering trend at the time was toward refinement and enlargement of size, which was reflected in SRP's engines. Although smaller designs were simpler, the large models offered higher capacity per unit.[10]

The cost of building the diesel plant was $1,183,668. The Association funded the construction; however, a 1948 internal report states that its ownership was "vested" in the U.S. Government. The plant was completed in 1938 with the units going on line in May and December of that year.[11]

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[9] General Machine Corp., "Instruction Book--Hamilton M.A.N. Diesel Engine," SRP Crosscut Steam Plant Office Files; Interview with Don Squire; Grasmoen, "Crosscut--Forty Years," 2.

[10] Howard E. Degler, "Five Years' Progress of Oil and Gas Power," Transactions of the American Society of Mechanical Engineers 61 (Oct. 1939), 589.

[11] Roe, "Brief History," 16.

C. Fuel. The engines were designed to use industrial-quality diesel oil. From early in their careers at SRP, however, a lower-quality fuel was used, probably for economical reasons. Because of this, the diesels had maintenance problems later that became quite expensive for the Project. At some point before the diesels were put out of regular service, SRP personnel experimented with other, less expensive fuels, including heavy oil and natural gas. Two supervisors of the plant thought the units could operate economically on natural gas, but by the time they reached this conclusion, upper management had decided to retire the diesel plant.[12]

D. Operation and Production. Relative to other parts of the Project's electric system, the diesel plant had a short working life. Its peak production years were 1939 and 1940, after which power from Parker Dam was available to the Association via a U.S. Bureau of Reclamation contract. In 1945 the plant's net delivered output rose again when post-war industry boomed in Phoenix (see Fig. 3).

Originally, engineers designed the diesel plant to be operated separately from the hydro plant that already existed at the Crosscut site. However, when the plant was finished, the

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[12]Interview with Don Squire; Interview with John Rich, Phoenix, Arizona, Dec. 4, 1990.

Fig. 3

DIESEL PLANT NET DELIVERED POWER 1938-45

Year	Net KWH
1938	5,882,100
1939	46,023,200
1940	55,693,600
1941	20,222,070
1942	5,174,170
1943	8,303,180
1944	7,335,090
1945	13,411,670

Source: SRP Annual Histories 1938-45 (SRP Archives).

diesel plant's electrical control board was located in the hydro plant structure to be operated by the employee responsible for the hydro control board. This was partly due to a separation of labor that existed at that time. There were men who operated the electrical systems and different men to run the boilers and water systems and other machinery. Since there was already an electrical control employee for the hydro plant, it made sense for him to operate the diesel controls as well. In modern diesel and hydro plants, one person can do all the work required.[13]

The diesel engines at Crosscut were installed to produce 25-cycle power. When Salt River Project began the program to convert its system to 60-cycle in 1949, the diesels were not converted. Power from the diesel plant continued to supply the mining customers east of Phoenix.

D. Retiring the Diesel Plant. In 1949, the Association took the Crosscut diesel plant out of regular service due to high fuel and maintenance costs which made it economically less attractive than steam power. In addition, it would have been necessary to convert the engines to 60-cycle for them to be economical for the future. The Project used the diesel plant as a source of standby power until the mid-sixties, and in 1968 decided to sell the engines. This included marketing the units to Third World countries. No satisfactory sale was arranged,

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[13] Interview with Don Squire.

however, and in 1970 the Association sold the diesel engines to a scrap metal firm.[14]

IV. CROSSCUT STEAM PLANT

Only three years after the diesel plant was built at Salt River Project's Crosscut facility, the building was expanded to make room for steam generating units. The steam function soon came to dominate the diesel operation, and the entire building was recognized primarily as the Crosscut steam plant.

A. Background. In 1940, there was a severe power shortage at Salt River Project and the surrounding communities. Droughts had seriously affected hydropower supplies, and demand for electricity was growing in an expanding local economy. Salt River Project decided to install a steam generating plant at its Crosscut facility that year, and by 1941 three steam units were operating.

Almost immediately, the war economy in the SRP service territory began to grow rapidly as new military facilities, industries supporting the war effort, and workers moved into the Salt River Valley. The additional power from the steam plant was an essential part of SRP's efforts to meet the new demand. This growth continued through the forties and fifties, so that by 1960

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[14] Interview with John Rich; Parsons, Brinckerhoff, Hall and MacDonald, Engineers, "Report on Additional Power Generating Facilities for the Salt River Project Agricultural Improvement and Power District, Phoenix, Arizona" (New York: Dec., 1952), SRP Archives Library, 14; Interview with Don Squire; L.M. Alexander to George Nielsen, May 6, 1968, SRP Archives; F.N. Smith to Lin Bowling, August 17, 1970, SRP Records Mgmt.

the Phoenix population had increased 311%, from 65,414 in 1940 to 439,170 twenty years later.[15]

Steam generation was a logical choice for Salt River Project, as it was common in the utility industry. From before the turn of this century, steam power has been an important part of industrial America. C.A. Parsons designed the "first practical multi-stage [steam] turbine" in 1884, and his designs were standards for several decades.[16] Steam power plants were the primary provider of energy for industrial purposes in the United States in the late twenties. By the time SRP built the Crosscut steam plant, steam generation accounted for approximately 65% of all electricity produced at stationary power plants.[17]

Steam units could be located at the Crosscut site because there was ample water available from wells and canals in the vicinity. Steam plants typically did not compete economically with hydro units, but could be operated in conjunction with them in a mutually beneficial way.[18]

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[15] Luckingham, Phoenix, 153.

[16] F.R. Harris, "The Parsons Centenary--A Hundred Years of Steam Turbines," Proceedings of the Institute of Mechanical Engineers 198A No. 9 (1984), 183.

[17] G.F. Gebhardt, Steam Power Plant Engineering (New York: John Wiley and Sons, Inc., 1928), 1; Thomas E. Butterfield, Burgess H. Jennings, and Alexander W. Luce, Steam and Gas Engineering (New York: D. Van Nostrand Company, Inc., 1947), 2.

[18] Butterfield, et al., Steam and Gas, 1; Zerban and Nye, Power Plants, 3.

B. Construction and Design. By September 20, 1940, the Association had contracted with C.C. Moore and Co. Engineers, Inc., of San Francisco, California, for engineering, equipment, and construction of most of the Crosscut steam plant. Salt River Project engineers were responsible for designing some of the electrical work. The first three units were installed during the following year and began trial operation in November and December, 1941. In May 1942, Salt River Project formally accepted the plant and the trial period ended.

The three original turbine generators were 25-cycle, 9375 KVA, 7500 KW units manufactured by General Electric. They featured "impulse blade path design" rather than reaction design, the traditional Parsons design of the late nineteenth and early twentieth century (See Appendix B for additional engineering details). Three boilers produced the supply of steam and were designed to run on natural gas or fuel oil. These were made by the Babcock and Wilcox company, and the condensers by Worthington. To install the new machinery, it was necessary to expand the existing building, and to lower the floor four feet below that of the diesel plant area. In addition, the Southern Pacific Company installed two industrial spur railroad tracks to the south end of the structure.[19]

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[19]Interview with Don Squire; F.S. Cummings to H.J. Lawson, Oct. 25, 1940, SRP Archives; Contract between Salt River Valley Water Users' Association and Southern Pacific Co., April 7, 1941, SRP Archives.

All the equipment was considered standard for the period, and the overall plant design was not uncommon. In fact, one former manager of the steam plant described the cycle design as perhaps a bit outdated, although very suitable for a utility the size of SRP. It was a simple, "classic header system" in which the turbines were connected to a main steam header and could operate in conjunction with any of the boilers. This was a standard arrangement in the utility industry at the time.[20]

To finance the construction of the plant, the Association used funds collected by a $2,500,000 District bond issue. In 1940 it was estimated that the entire project would cost $2 million, but in 1948 the actual costs incurred were over $2,600,000. As with the Crosscut diesel plant, one record from the construction period states that ownership of the steam facility was "vested in" the U.S. Government.[21]

C. Additions to Steam Plant. The Crosscut steam plant became operational at the very outset of a period of rapid load growth for the Salt River Project. To meet some of the new demand, the Association augmented the capacity of the steam plant by leasing a U.S. Navy mobile steam generating unit from 1946-8, adding a fourth permanent turbine generator in 1949, and installing three additional boilers in 1950.

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[20] Interview with Don Squire.

[21] F.C. Henshaw to Stevens Manning, Sept. 20, 1940, SRP Archives; Roe, "Brief History," 17.

1. Mobile Unit. After the end of World War II, the Project faced inadequate power supplies to the point of rationing power in some instances. Probably through political relationships at the U.S. Bureau of Reclamation, the Association arranged with the U.S. Navy to rent one of two mobile steam generating plants designed as emergency power sources for shipyards or bombed areas. The two identical units were built on railroad cars during the war by General Electric. One was located at the Mare Island Navy Yard in San Francisco Bay, California, and the other at Philadelphia. The Project rented the Mare Island unit.[22]

Salt River Project was "one of seven urgent applicants for use of [the] unit," and took delivery of it in 1946.[23] The Navy had never used it during the war. The plant consisted of six cars holding a boiler and auxiliaries, steam turbine generator and auxiliaries, electrical switchgear, a transformer and other auxiliary equipment. All this was similar enough to the Crosscut steam plant machinery that Project employees could operate it with relative ease. Personnel from the Mare Island yard accompanied the railroad cars to the Crosscut facility and remained for about three months to set it up and train Association crews. A new railroad spur line was required to bring the cars near the existing plant. According to one source,

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[22] "The steam electric generating plant...," Current News (July 1946), 3; Interview with John Rich.

[23] "The steam-electric generating plant...," 3.

the Association paid the Navy $100.00 a day to rent the mobile steam plant.[24]

By early 1948, the Association was making plans to return the unit. The Navy wanted it back, and the Association had ordered a fourth turbine generator to install in the Crosscut steam plant for additional power. In late summer of 1948, a Crosscut supervisor accompanied the mobile unit on a four-day rail journey to Mare Island.[25]

2. Fourth Steam Unit. To supplement the original Crosscut steam plant and replace power provided by the Navy mobile plant, the Association installed a fourth steam unit in 1949. This had 8,000 KW capacity and produced 60-cycle power from the outset (the original three units were 7,500 KW; two of them were converted from 25-cycle after 1949). Like the original three units, the fourth steam turbine used impulse blade path design (See Appendix B).

3. Additional Boilers. In the late 1940s the Association added three new boilers to the steam plant to supply steam for the fourth unit. These were compact "express type" marine boilers featuring single-pass, header-type design and manufactured by the Babcock and Wilcox company, which also built the steam plant's original boilers. The marine units were built

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[24]Ibid., Interview with John Rich; "Crosscut," Current News, 8.

[25]Charles E. Blaine to O.L. Norman, April 16, 1948, SRP Archives #2460-4; Interview with John Rich.

for Navy ships but had never been used, and were sold as surplus material after the war. They were considerably smaller than the steam plant's other boilers, and contained turbine-driven fans which were unusual for a utility to use.[26]

D. Fuel. The cost of fuel historically was one of the largest single expenses incurred in steam power generation, often amounting to half the total operating costs.[27] Fuels were an important part of the Crosscut power production system, to the degree that their costs could help determine whether a plant stayed open or not.

At the steam plant, the primary fuels were oil and natural gas. Originally, it used mainly residual fuel oil of the standard specification for most utilities in the western United States. The Association received shipments of oil by rail. In the early forties, the first natural gas was used in the steam plant, and this use increased with the addition of a natural gas line supplying the Crosscut site after the end of the war. This was a six-inch line installed between the steam plant and a distribution site for El Paso Natural Gas located at 13th Street and Hardy in Tempe. Throughout the mid-forties, the steam plant burned both oil and natural gas. Natural gas was increasingly the fuel of choice as it was cheaper to buy and cleaner to burn

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[26]SRP historic photos dated 1947 show the three marine boilers being installed that year; other sources say they were put in later; "Crosscut," Current News, 8; D.P. Vail to O.L. Norman, April 29, 1947, SRP Archives; Interview with Don Squire.

[27]Gebhardt, Power Plant Engineering, 25.

than oil. By 1952, it appears that the Project was using only natural gas in the steam plant. The fuel cost was $.19 per 1000 cubic feet; the Association's total cost for natural gas in 1951 was $733,603.[28]

Fuel for the mobile steam plant for its short career at Salt River Project was also important. The unit used both oil and natural gas, probably in similar proportions to the stationary steam plant.

D. Plant Laboratory. The steam/diesel plant building housed a laboratory that the Association used primarily to monitor and regulate chemical balances in water used in the machinery. This included checking feedwater and boiler water for oxygen, pH balance, hardness, chlorides, solids, alkalinity, phosphates, oil, organic matter, and other substances. Other possible functions were testing oil samples and preparing and analyzing other solutions required in operating the equipment. The Project employed at least one chemist to staff the laboratory.[29]

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[28] Interview with Don Squire; Interview with John Rich; "Steam Costs," unpublished report, SRP Archives; Parsons, et al., "Additional Power Facilities," 15.

[29] W.L. Relfe to J.A. West, Dec. 17, 1947, SRP Archives; Babcock and Wilcox Co., "Instructions for the Care and Operation of B & W Equipment for the SRVWUA, Phoenix, Arizona, for Tempe, Arizona," SRP Archives; "Crosscut Steam Plant Lab Manual," SRP Archives.

E. Indian Bend Pond and Pump Ditch. The Association used a combination of water sources to supply the various needs at the overall Crosscut facility. These included wells, the Grand Canal which runs just south of the Crosscut site, and a small waterway called the Indian Bend pump ditch. The water systems for the steam plant were an important part of the facility design. An integral part of the steam plant operation was a small pond used to hold water from the Indian Bend pump ditch. Its primary purpose was to supply "makeup" water to the cooling tower for the steam plant. This was one of the most important water systems at the Crosscut facility.[30] (See Photos HAER No. AZ-20-A)

The Indian Bend ditch was originally built as a channel for waste irrigation water. In 1921, Association Engineer T.A. Hayden arranged with property owners east of the Crosscut site for the construction of a ditch to move water from their land to the Salt River bed. The ditch head was located near a natural drainage channel known as Indian Bend Wash, then travelled generally south and west to the river bed. Probably in the late 1930s, the ditch was connected to the Association's Grand Canal near the Crosscut facility site to make use of the ditch water in

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[30]Interview with Don Squire. The pond has mistakenly been called a "fire pond" and its purpose thought to be providing water to put out fires. Another water system, not connected to the Indian Bend pond, existed for this purpose at the steam plant, although pond water may have been used in an emergency. Correspondence with C.C. Moore and Co., the steam plant engineers, confirms that the main purpose for the pond was to provide makeup water to the cooling tower (files in SRP Archives).

the Project's irrigation system. The Association also installed wells in the Indian Bend area to augment its water supply, and the ditch carried this water as well. By 1967, two other sources of water occasionally appeared in the ditch: street drainage from the City of Scottsdale, and storm water from the Indian Bend Wash.[31]

Like the ditch, the site of the Indian Bend pond also was in use before the steam plant was built. The first structure there was a pumphouse containing a shallow well to supply water to the Crosscut diesel plant. The water table was only about 24 feet below the surface in that location. In 1939, the Project approved work on the Indian Bend ditch to include underground piping of a segment. In 1941, the Association and its consulting engineers were planning the construction of the steam plant, and decided to use water from the Indian Bend pump ditch in the circulating water system. Several 25-cycle pumps were installed near the former diesel plant well, and a holding pond excavated. The pond was constructed so that only pump ditch water would normally collect there, but water from the Grand Canal could also be used if necessary. The engineers considered putting the pump

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[31] SRP, "A Study of the Indian Bend Wells and Irrigation Facilities: Their Use and Improvement," by R. Juetten, ca. 1961, SRP Records Mgmt., 4-5; 1938 SRP Annual History; A. Lee Talbot to Chet Andrews, July 21, 1967, SRP Records Mgmt.

controls at the steam plant but finally decided to install them at the pond site itself.[32]

Over the span of its useful life, the Indian Bend pond primarily provided makeup water for the cooling tower of the steam plant. However, in the early years of the steam plant, the Association used pond water for the condensers in the circulating water system for the plant. Water was pumped to basins near the cooling tower, through the condensers, and then returned to a channel leading to the Grand Canal. To make the most of the water, the Project installed a small (175 kw), 25-cycle hydro generating unit on the bank of this channel, the tailrace of the Crosscut Canal, directly across from the main Crosscut hydro plant. Water that had been used in the condensers passed through the hydro unit on its way back to the Grand Canal. This system apparently was fairly successful from an engineering standpoint, but the water contained minerals which, over time, built up on some of the machinery controlling water flow. This caused enough problems in the overall circulating water system that the entire steam plant occasionally had to be shut down. Eventually the small hydro unit was shut down. It remains standing today, but has not been maintained.[33] (See Photos HAER No. AZ-20-B)

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[32]Diesel plant right of way drawing, 1940; Indian Bend Pump Ditch Work Order, approved Dec. 4, 1939, 1939 SRP Annual History; H.J. Lawson to F.S. Cummings, Feb. 21, 1941, SRP Archives; Interview with Don Squire; Interview with John Rich; 1941 Correspondence with C.C. Moore and Co., SRP Archives.

[33]Interview with John Rich; Interview with Gene Ayers, Salt River Project, Nov. 9, 1990.

After the Indian Bend pond was constructed, there were few substantial additions or alterations. However, the Project faced problems with trespassers in the fifties and sixties because the pond became known as "one of the best fishing holes in the [Salt River] Valley."[34] Fishermen frequently destroyed the fences around the pond. In addition, vandals had destroyed considerable amounts of property in and around the pumping plant. In the late fifties, Project management was very concerned about these problems because of the importance of the pond to the operation of the steam plant, and also because of the safety hazards they posed. In 1956 and again in 1972, new fencing was installed to try to keep trespassers out. It is possible that other new fences had to be put in at other times as well.[35]

At least by the early seventies, the Association had abandoned the Indian Bend pumping plant (the steam plant last produced power for the SRP electric system in 1974).[36] The pond and a portion of the pump ditch near the Crosscut facility were destroyed in 1990 to facilitate re-routing of Washington Street in Tempe.

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[34] D.L. Weesner to C.H. Whalin, August 7, 1972, SRP Records Mgmt.

[35] T.M. Morong to F.E. Ealy, Feb. 14, 1956, and Preliminary Construction Budget Request for Chain Link Fence at Indian Bend Pumping Plant, Aug. 29, 1956, both from SRP Records Mgmt.

[36] A May, 1967 memorandum from Chet Andrews to Bob Earll, both of SRP, indicates that the pump ditch near the pond was in a state of disrepair, and likely disuse, at that time. From SRP Records Mgmt.

F. **Use and Operation of Steam Plant.** The Crosscut steam plant, augmented by the diesel plant, was Salt River's only source of self-generated power not produced by hydroelectricity during the high-growth years of the forties. As such, it was an important part of the electric system, without which the Project might not have met its customer needs. In the early fifties, Salt River built a second steam plant, the Kyrene Generating Station, at Tempe. After this time, the Crosscut steam plant was not needed for full capacity operation to the degree it had in the past, although it continued to produce power for about twenty more years.

In 1957, national power costs were comparable to what they had been in 1939. Although loads had increased greatly, operating efficiency promoted throughout the industry was successfully keeping costs down. Management at the Crosscut steam plant worked hard to meet high standards for operation and safety. From 1955-65, plant personnel received company awards for "no lost time accidents," skipping only the year 1960. The plant's cleanliness, "one of the hallmarks of operating efficiency," was especially noteworthy.[37]

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[37] Zerban and Nye, Power Plants, 1; "John Pioneered Concepts that Shaped SRP," Project Pulse 24:28 (July 20, 1989), 8; Crosscut steam plant office materials; Captain Burr W. Leyson, The Miracle of Light and Power (New York: E.P. Dutton & Co., 1955), 27.

G. Retiring the **Steam Plant**. Sometime in the early seventies, the Project decided to discontinue operation of the steam plant. Throughout that decade and in light of uncertainties in the national power industry, Salt River kept open the possibility of starting up the steam plant again. In 1978 it appeared that to do this would require major work on the cooling tower, which was in a state of serious disrepair. In actuality the plant never did produce power for the electric system after 1974.[38]

The Project sold some of the steam plant machinery for scrap. Today, the turbines and boilers remain in the building along with various other parts. It was considered more expensive to move these than to leave them in place.[39]

V. SUMMARY AND CONCLUSIONS

The Crosscut facility at Salt River Project is historically significant in many ways. The entire site is one of the oldest continuously operating locations in the Project. It was here that the company first branched out from hydropower, first to diesel and then to steam electric generation. Historically, the site was unique because hydro, steam, and diesel generating operations functioned simultaneously, an unusual occurrence in

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[38] Interview with Don Squire; M.M. Hitt to Randy Dietrich, Nov. 13, 1978, SRP Records Mgmt.; Carl Sparks to John McNamara, April 19, 1979, SRP Records Mgmt.

[39] Interview with Don Squire.

the utility industry. It was made even more so by the addition of the railroad-mounted mobile steam plant after World War II.

The Crosscut diesel plant was an important generating resource during its regular operating career, 1938-49. It offered relief from dependence on water power and, as such, marked the first departure from an electric system built wholly on hydro generation. In 1939 and 1940, it was especially productive before Salt River Project began receiving purchased power from Parker Dam. The diesel plant is significant in the history of engineering because the engines it contained were large, complex, and rare in the United States. Very few units like them were operating in the country when the SRP plant was built, and this type of engine was the largest capacity operating in America.

The steam plant at Crosscut was important to the company because it produced reliable power during a high growth period, particularly the forties and fifties. In addition, it was the first of several projects in steam generation in which SRP participated. The plant represents standard design and machinery for the period in which it was built, as well as some unique features. It was unusual that SRP acquired rights to rent the mobile steam plant from the U.S. Navy in the immediate post-war years. This unit furnished much-needed power for the expanding local economy in the period before Salt River Project installed the fourth unit in the Crosscut steam plant. In addition, the three marine boilers added to the steam plant in 1950 were unique simply because they were designed for use on a ship. The steam plant as a whole was an integral part of the SRP electric system during its operational life.

(For additional information on the Crosscut Hydro Plant, see HAER No. AZ-30)

APPENDIX A

CROSSCUT DIESEL PLANT ENGINEERING DETAILS

2 Engines Identical
7,000 hp Rating 167 rpm
8 cylinder, 2 cycle, double acting, crosshead piston design.
    Water cooled pistons and fuel valves (injectors); solid injection.
Electric motor operated scavenging air blower - 400 hp
Closed cooling system: common to two engines
Heat exchanger cooling medium: irrigation canal water or fluor atmospheric cooling tower.

<u>Lube Oil System</u>
    Centrifuge and Fullers earth filters used on sump oil.
    Straight mineral oil (no detergent).
    Sump capacity 1100 gals.
    Electric auxiliary oil pump for starting and stopping.

<u>Fuel System</u>
    9600 bbl. main storage tank
    3 - 1000 gal. day tanks
    2 - Sharples centrifuges
    2 - Honan-Crane filters

<u>Electrical System</u>
    General Electric Generators, Direct Connected Exciters
    6250 KVA
    6600 Volts
    5000 KW
    25 Cycle
Normal Operating Load - 3600 KW
Maximum Emergency Load - 4200 KW

<u>Starting System</u>
    Compressed air - 900 psi
    2-stage compressor
    4 - storage bottles

<u>Fuel</u>
    22 gravity
    5% carbon residue
    1.5% sulphur
    Daily consumption 150 bbls./24 hrs./engine at 3600 KW

Source: Equipment Inventory, ca. 1950, SRP Archives #3175-1.

Engine Construction. "The engine is of the double-acting, two-cycle, diesel type, with 8 cylinders of 24" diameter and 36" stroke. The effective area on the lower cylinder is 86.7% of the area of the upper cylinder. The engine normally develops approximately 6850 bhp, at 167 rpm, with an effective mean pressure of 66# per square inch, and with a corresponding indicated horsepower of 7600, which gives a mean indicated pressure on top of 75#, and bottom 72#. This gives the engine a mechanical efficiency of 90%.

The main features of construction are:
a) Vertical type with crosshead construction.
b) The injection of the fuel is of the so-called Solid Injection System.
c) Each cylinder side has its own fuel pump. For the lower side, a special distributor is provided to take care of the even distribution to both the fuel valves. The regulation of the fuel oil supply is controlled by the governor, keeping the engine at normal speed for all loads. The overspeed governor shuts the engine down should the speed exceed 16% above normal. The hand control of the fuel is used in starting.
d) The scavenging air is supplied by electrically operated Turbo Blower."

Working Principles of Engine. "The engine operates on the double-acting, two-cycle principle; i.e., at each revolution, both on top as well as on the bottom, the compression stroke, firing, and expansion stroke occurs, at the end of which the exhaust and scavenging takes place.

The scavenging of the cylinders is carried out on the M.A.N. patented port scavenging loop system, where the scavenging air is blown into the cylinder through ports arranged below the exhaust port on the same side of the cylinder. Both scavenging and exhaust ports are controlled by the piston. The scavenging air sweeps across the piston and is deflected by the piston to the opposite cylinder wall towards the top, then returns along the cylinder head and flows back along the other side of the cylinder wall to the exhaust ports. On the bottom side the scavenging port is directed in such a way that the scavenging air passes on both sides of the piston rod without interference from it. The engine is started by the use of compressed air; each lower cylinder side has one starting valve, which is automatically operated as soon as the starting air line is put under pressure. By starting, some fuel oil is admitted to the fuel valve, and as soon as the first firing occurs, the starting valve acts as a check valve and prevents further starting air from being admitted to the cylinder."

Source: Quoted from General Machinery Corp., "Instruction Book, Hamilton-M.A.N. Diesel Engine," (Hamilton, Ohio), Crosscut steam plant office, 9-11.

APPENDIX B

CROSSCUT STEAM PLANT ENGINEERING DETAILS
(After 1951)

TURBINE ROOM DESIGN DATA

Turbines #1 and #2 - 60 cycle
General Electric Turbine and Generator
60 cycle, geared unit (converted from 25 cycle)
Turbine speed 3460 rpm
Generator speed 720 rpm 10 pole
Throttle pressure 410 psig
Throttle temp. 750° F.
16 stages
Bleed points for regenerative feedwater heating
4th stage - feedwater heater and evaporator coils
9th stage - " "
13th stage - " "
Generator ratings
7500 KW
9375 KVA
6600 Volt

Turbine #3 - 25 cycle
Turbine and gear reducer identical to Units #1 and #2
Turbine speed 3608 rpm
Generator speed 750 rpm
Generator ratings
7500 KW
9375 KVA
6600 Volt

Turbine #4 - 60 cycle
Direct Connected Unit - General Electric
Turbine and Generator Speed 3600 rpm
15-stage turbine
Bleed points
6th stage - evaporator coils
11th stage - feedwater heater
Generator ratings
7500 KW
9375 KVA
12500 Volt

Normal Operating Load All Machines 8500-9500 KW

BOILER ROOM DESIGN DATA

Boilers Nos. 1, 2, 3 - Babcock and Wilcox 100,000 #1 hr. integral furnace boilers

Boilers Nos. 4, 5, 6 - Babcock and Wilcox 37,500 #1 hr. marine type boilers.

Superheater outlet pressure - 415 psi
Superheater outlet temperature - 750° F.
Feedwater temperature
Boilers Nos. 1, 2, 3 - 365°
Boilers Nos. 4, 5, 6 - 260° inlet to economizer

Fuel System

Natural Gas
Supplier - El Paso Natural Gas Company
Require approx. 11,750,000 cf/day
Gas pressure from EPNG - 150-250 psi
Gas pressure at burners - 4-7 psi
Fuel Oil - Standby fuel
Obtained from Pacific coast rail delivery
Require approx. 1800-2000 bbl./day - full load on oil
Pressure at burners - 125-250 psi
Temperature as fired - 210-230°

Boiler Feed System
Approximately 1% makeup water
Water is filtered, Zeolite softened and double distilled
Storage for condensate - 30,000 gal.

Main Feed Pumps
1 steam turbine drive, centrifugal standby
4 electric, centrifugal

Feedwater Control
Boilers Nos. 1, 2, 3 - Bailey - 3 element
Boilers Nos. 4, 5, 6 - Copes - 2 element

Combustion Controls
Boilers Nos. 1, 2, 3 - Bailey
Automatic firing of either oil or gas
Boilers Nos. 4, 5, 6 - None

CONDENSING AND CIRCULATING WATER SYSTEM

Units Nos. 1, 2, 3

Marley cooling tower
10-cell
Induced draft
Fan diameter 156"
Motor - 30 hp
Quantity circulated - 45,000 gpm
Wet bulb approach - 17° design

Circulating Water Pumps

3 - 15,000 gpm Ingersoll Rand

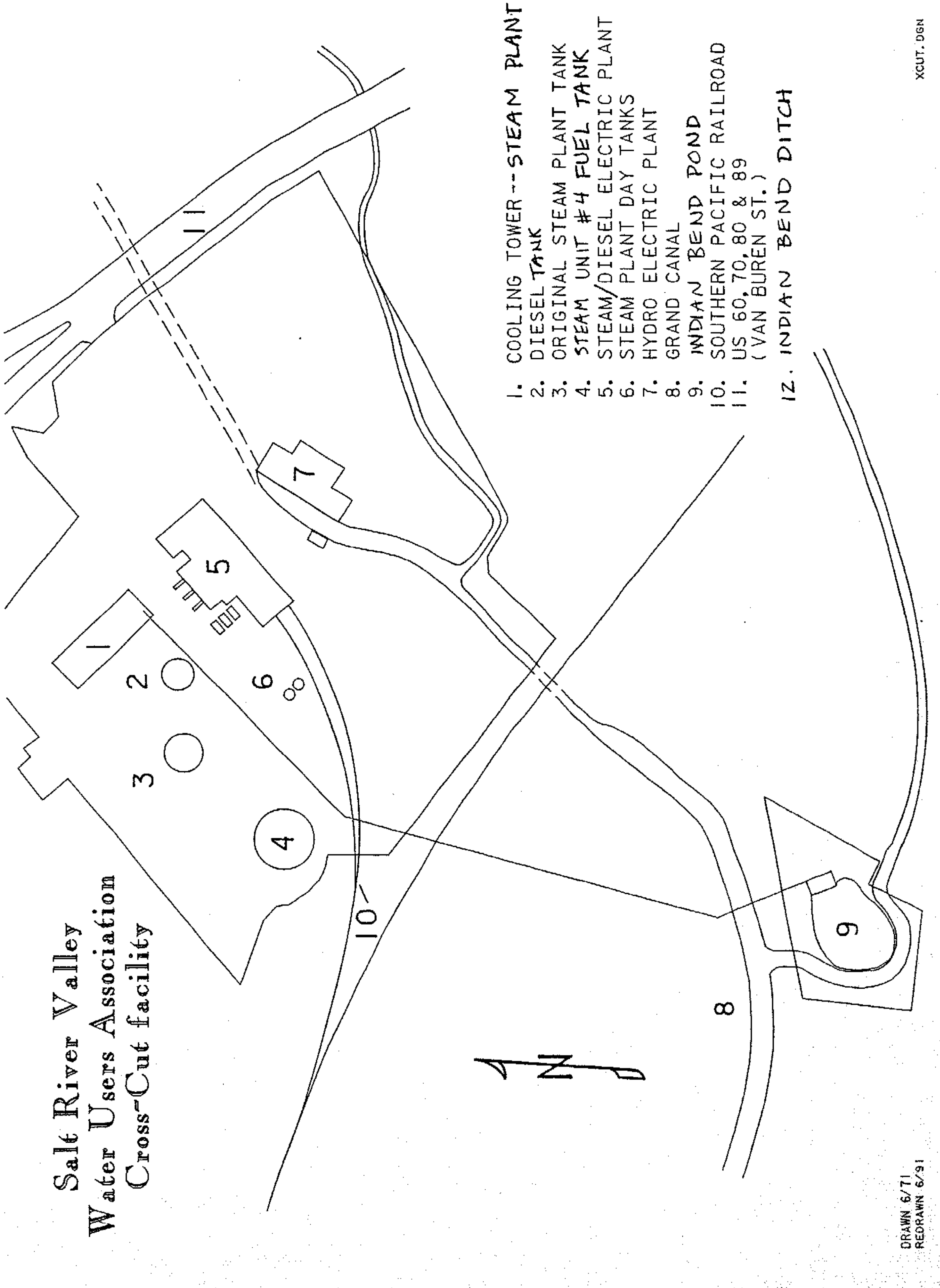
Condensers

3 - Worthington
8960 sq. ft. surface
Divided water box; 2-pass

Unit #4 Cooling

Water from Cross Cut canal - no pumps
Once through system
Condenser
Worthington - 9000 sq. ft.
Divided water box; 2-pass

Source: Equipment Inventory, ca. 1950, SRP Archives # 3175-1.


Salt River Valley
Water Users Association
Cross-Cut facility
1. COOLING TOWER -- STEAM PLANT
2. DIESEL TANK
3. ORIGINAL STEAM PLANT TANK
4. STEAM UNIT #4 FUEL TANK
5. STEAM/DIESEL ELECTRIC PLANT
6. STEAM PLANT DAY TANKS
7. HYDRO ELECTRIC PLANT
8. GRAND CANAL
9. INDIAN BEND POND
10. SOUTHERN PACIFIC RAILROAD
11. US 60, 70, 80 & 89
(VAN BUREN ST.)
12. INDIAN BEND DITCH
N
XCUT.DGN
DRAWN 6/71
REDRAWN 6/91